3 PLANNING FINAL STATUS SURVEYS: DATA QUALITY OBJECTIVES

An essential consideration in designing survey plans for site decommissioning is that the radiological data that are collected and analyzed are sufficient and of adequate quality for decision-making purposes. *It is imperative that the type and quality of radiological data that will be needed to support license termination be considered early in the decommissioning process.*

Before commencement of survey work, it is essential that a survey plan be developed that is based on the data needed for decision making and the level of quality needed to support the decision. Such a plan should specify what samples need to be obtained, how and where they will be collected and analyzed, what quality assurance procedures will be used, the method of comparing site areas to reference areas, and what level of decision errors will be considered acceptable. These decisions become paramount for determining compliance with decommissioning criteria that are near background levels.

3.1 Introduction

The Data Quality Objectives (DQO) process is a series of planning steps based on the scientific method that is designed to ensure that the type, quantity, and quality of environmental data used in decision making are appropriate for the intended application (EPA QA/G-4, 1994). DQOs are qualitative and quantitative statements that

- clarify the study objective
- define the most appropriate data to collect
- determine the most appropriate conditions for collecting the data and
- specify acceptable levels of decision errors that will be used as the basis for establishing the quantity and quality of data needed to support the decision.

The DQO process comprises the following steps:

(1) State the problem, i.e., the objective of the sampling effort.
(2) Identify the decision, i.e., the decision to be made that requires new data
(3) Identify inputs to the decision, i.e., the data that are needed and how they will be used to support the decision.
(4) Define the study boundaries, i.e., the spatial and temporal aspects of the environmental media that the data represent.
(5) Develop a decision rule, i.e., an “if...then” statement that defines the conditions for choice among alternative actions.
(6) Specify limits on decision errors.
(7) Optimize the design for obtaining data, i.e., the most time- and resource-effective sampling and analysis plan.

The DQO process is iterative, so that any and all of the specifications may change as new information is obtained during the course of site remediation, up until the final status survey is *actually performed.*

It is important to specify the type and quality of radiological data that will be needed for final status surveys *early* in the decommissioning process. This process entails early specification of sample collection and analysis procedures, the determination of DCGLs, the classification of survey units, the method of comparing survey units to reference areas, the null and alternative hypotheses, Type I and Type II error rates, and quality assurance procedures.

In the following sections, each of the seven steps in the DQO process is discussed as it pertains to the planning, design, and performance of the final status survey.

3.2 State the Problem

For most NRC licensees, the objective of the decommissioning process is to remove their facilities safely from service and reduce residual radioactivity to a level that permits release of the property and termination of the license. The data that will be needed to support this objective will demonstrate that any residual radioactivity remaining on the site results in a dose that does not exceed the release criterion. *This objective will be met by performing a final status survey in individual survey units. For each survey unit, a separate decision will be made on the attainment of the release criterion.*

The final status survey occurs near the end of the decommissioning process, following historical site assessment, scoping, characterization, and remediation. These earlier steps in the decommissioning process provide crucial information for the design of the final status surveys. This information includes the identification of potential residual radioactive materials, the general locations and extent of residual radioactivity, and estimates of the concentration levels and its variability. Some of this information may be part of the licensee's decommissioning plan.

3.3 Identify the Decision

For the final status survey, the essential decision is whether the decommissioning criteria have been met in individual survey units. The decommissioning criterion is expressed in terms of a total effective dose equivalent (TEDE) limit above background due to residual radioactivity. The decision will be based on radiological data collected in a survey designed for this purpose. Procedures for the design of the final status survey and for the statistical analysis of the results are the primary focus of this report.

An essential part of identifying the decision, is a knowledge of the applicable residual radioactivity concentration limits. These are the Derived Concentration Guideline Levels (DCGLs) discussed in Section 2.2.1. NRC has developed models to provide generic dose conversion factors for residual radioactivity that can be applied within a hierarchy of modeling approaches. The models provide a mechanism for translating the residual radioactivity at a site into TEDE using the site-specific source term and varying levels of related site information. The provisions of 10 CFR Part 20, Subpart E require that a licensee consider the entire applicable source term and all credible dose pathways when determining whether any residual radioactivity meets the decommissioning criteria.

Since the dosimetric models are used to define the TEDE release criterion in terms of a DCGL, careful consideration should be to the assumptions made in those models. Screening models are generally the easiest to use. These models are constructed to cover a wide range of possible conditions, and so are also generally the most conservative. Their use may result in very low DCGLs. Using site specific parameters in such a model can reduce this conservatism considerably, but will require some justification. A balance should be sought between the complexity of site specific modeling and the potential cost in remediation and surveys of using DCGLs that are overly conservative.

For sites which contain residual radioactivity distinguishable from background from more than one radionuclide, there are two methods that can be used. If the concentrations of the radionuclides within a survey unit are related, one radionuclide can be used as a surrogate for the others using a modified $DCGL_W$. Otherwise, the TEDE due to the mixture of radionuclides is compared to the release criterion by applying a *mixture rule*. This is done by determining the ratio between the concentration of each radionuclide in the mixture and the $DCGL_W$ for that radionuclide alone. The sum of the ratios for all radionuclides in the mixture should not exceed one. The case of multiple radionuclides is discussed further in Chapter 11.

3.4 Identify Inputs to the Decision

Although the final status survey is performed near the end of the decommissioning process, it is possible to produce a more efficient survey design if the requirements of this survey are identified early in the decommissioning planning. By knowing in advance the type, quantity, and quality of data that are needed in the final status survey, information obtained from earlier decommissioning surveys may be used to support the final status survey.

Previous steps in the DQO process have identified the critical radionuclides, and established their corresponding concentration or surface activity limits (DCGLs) for various post-remediation land use scenarios. In subsequent steps, acceptable limits on decision errors, and the number of measurements necessary to meet them, will be established. To accomplish this, an estimate of the expected variability of the measurement data will be needed. Information from scoping, characterization, and remediation control surveys can be very useful for estimating the mean and standard deviation expected for residual radioactivity in a survey unit and for background radioactivity in one or more reference areas. In the absence of such data, experience and scientific judgment can be used to estimate the expected measurement variability or a separate scoping survey may be conducted. The effort required for an adequate estimate of the expected measurement variability will depend on its magnitude relative to the DCGLs. The smaller the value of the DCGL relative to the expected measurement standard deviation, the more important it will be to have an accurate estimate of that standard deviation. Thus, surveys performed earlier in the decommissioning process can provide valuable information for designing the final status survey. As more information comes available, both the measurement and statistical methods that will be needed to meet release criteria can be refined.

The selection and proper use of appropriate instruments and techniques will be critical factors in assuring that the survey accurately determines the radiological status of the site. In this report, three basic types of measurements are considered:

(1) scanning
(2) direct field measurements
(3) laboratory analysis of samples.

Scanning is the process by which the surveyor moves a portable radiation detection instrument over a surface (i.e., ground, wall, floor, equipment) to detect the presence of radiation. A scan is performed to locate radiation anomalies that might indicate elevated areas of residual activity that will require further investigation or action. If scan survey results exceed a scanning action level determined on the basis of the potential contaminant and the detector and survey parameters, the location is noted for further action (direct measurement or sampling).

Direct field measurements are those made at a fixed location using portable instruments (e.g., survey meter, pressurized ionization chamber (PIC), *in situ* spectrometer). The result of a direct measurement, as opposed to a scan, is a quantitative measure of the radioactivity present at the location measured.

Taking samples, with subsequent analyses conducted in a laboratory, will be required for certain radionuclides and radiations that cannot be adequately detected using direct measurements. For some nuclides or environmental media, this may be the only realistic technique to employ.

The analysis techniques used may be *radionuclide specific* or for *total radioactivity*.

The survey designs with which these measurements are made fall into two categories:

(1) authoritative (judgment) sampling
(2) probability sampling

Authoritative or *judgment sampling* occurs when measurements are made or samples are collected at locations where anomalous radiation levels are observed or suspected. The term "biased sampling" is sometimes used to indicate that the sample locations are not chosen on a random or systematic basis. Biased radiological measurements and samples also may be taken to further define the areal extent of potential contamination and to determine maximum radiation levels within an area.

When data quality objectives involve statistical estimation or hypothesis testing, some form of *probability sampling* is required. The type of probability sampling recommended for use in final status surveys is either simple random sampling (for Class 3) or systematic sampling on a systematic grid with a random start (for Class 1 and Class 2).

Of the three measurement types, only the results of direct measurements and sampling are used in conducting the nonparametric statistical tests. All three types of measurement result are subject to an elevated measurement comparison against an upper limit value.

The type of instrumentation or sampling and analysis methodologies or both used for final status surveys will influence the number of samples or direct measurements, or both, that are required for the appropriate statistical analysis of the data. As a rule, the less precise the measurement, the greater the number of measurements that will be required for the statistical tests to achieve the desired level of uncertainty. The selection of survey instruments may involve a cost analysis of whether it is better to use a more precise (and more expensive) measurement method with correspondingly fewer measurements, or to use a less precise (and perhaps less costly) method that would require the collection of more measurements. The information necessary to calculate the required number of samples, given the expected variability of the data, is discussed in discussed in Section 3.7.

Similar considerations are involved in the choice of making radionuclide-specific measurements versus total alpha, beta, or gamma activity or total exposure rate measurements or both. If total (gross) methods are used, the results will include the variability of natural background. This additional variability will not only require more measurements to overcome but will also necessitate comparison with a reference area using the two-sample Wilcoxon Rank Sum test of Chapter 6 rather than the one-sample Sign test of Chapter 5.

If the radionuclide of concern appears as part of background, there is no alternative to a survey unit comparison to a reference area; however, the measurement precision will still affect the number of samples required. Radionuclide-specific methods should be considered in this case as well, since the variability of the total activity present will be greater than that due to any particular radionuclide or series alone.

Instrumentation can be selected using guidelines that compare its performance capabilities to the applicable decommissioning criteria. Consideration should be given to the characteristics of the type of detector, in particular, the minimum detectable concentration (MDC) for the radionuclide under investigation. The simplest of devices, survey meters, may be appropriate for hand scanning of building surfaces for certain nuclides at certain activity levels. Fixed-place detectors at grid points can be used in other situations. In some situations, the sensitivity needed at background levels will require that measurements be nuclide specific, thereby requiring spectrometric techniques. Consideration should also be given to newer technologies as they are developed.

3.5 Define the Study Boundaries

Defining the spatial and temporal boundaries will help ensure that the samples taken in the survey are representative of the survey unit for which the decommissioning decision will be made. Spatial boundaries describe what measurements or samples should be taken and in what areas. Temporal boundaries describe when the measurements or samples should be taken, and any time constraints on the data collection and analysis. Uniformity over a given area should be checked wherever possible. This can be done by inspecting the site and knowing its history from data collected earlier in the decommissioning process, or by scanning measurements. The selection of measurement and sampling points must ensure that the sample is representative of the site category under investigation.

3.5.1 Spatial Variability

As has been discussed in Sections 2.2.6 and 2.2.7, some estimate of the variability of the data is needed for a good survey design. The smaller the variability within each reference area or survey unit, the smaller the number of samples that will be needed to achieve the specified Type I and Type II error rates for the test. Thus, it is advantageous to identify survey units that are relatively homogeneous in radiological character. Reference areas and survey units should be as similar as possible with regard to their background characteristics.

Considering the variability in collected data that is expected in any environmental sampling program, accurate interpretation of the results is essential. The choice of individual survey units and any reference areas to which they are to be compared is especially significant. In the analysis of the data, any systematic difference in the measurements from a survey unit and a referenece area is assumed to be due to residual radioactivity. The choice of a reference area is a spatial extrapolation of the background radionuclide concentrations there to the survey unit. It would be obviously inappropriate to compare uranium concentrations in soils collected from two sites of different geology, such as a sandy beach area and an inland region with heavy clay soil. In the case of the fallout radionuclide ^{137}Cs, concentrations in surface soils could only be extrapolated to other local plots of land that have received the same deposition (rainfall) and have the same history (for example, plowed agricultural land, forest, or undisturbed lawn). For instance, the presence of ^{137}Cs in soil, and the observation that it is not at the same level from place to place, does not necessarily indicate a local facility contribution. Such variations may have resulted from disturbance to the site through either natural or human action, which led to removal or addition of material containing fallout from atmospheric nuclear weapons tests, as well as differences in the spatial distribution of the original deposition.

In some situations involving radionuclides that appear as part of natural background, the screening level DCGLs may be small compared to the spatial variations among even nearby and closely matched reference areas and survey units. In such cases, an effort should be made to reduce exposure pathway modeling conservatism by using site specific parameters and realistic occupancy scenarios. In particularly difficult cases it may be necessary to explore alternative statistical methods for establishing whether residual radioactivity in a survey unit is distinguishable from background. An example of such an analysis is given in Chapter 13.

3.5.2 Temporal Variability

Temporal variability will contribute to the overall uncertainty of comparisons of survey units and reference areas, although generally to a lesser extent than spatial variability. However, it is best to avoid temporal variability to whatever extent possible. This might be accomplished by collecting data from areas to be compared over as short a time interval as possible, and avoiding circumstances known to cause short-term background variations. There may be reasons why samples cannot be taken in certain places or at certain times. These constraints should be identified so that they can be accounted for in the planning process.

3.5.3 Reference Coordinates

As part of this step in the DQO process, a site diagram should be prepared showing each potential survey unit and the reference area to which it will be compared. For each unit, the types of samples that will be taken, the analyses needed, and a schedule for sampling and analysis should be listed.

Reference coordinate systems are established at the site to facilitate selection of measurement/sampling locations and provide a mechanism for referencing a measurement to a specific location so that the same survey point can be relocated.

A survey reference coordinate system consists of a grid of intersecting lines, referenced to a fixed site location or benchmark. Typically, the lines are arranged in a perpendicular pattern, dividing the survey location into squares or blocks of equal area. Reference coordinate system patterns on horizontal surfaces may be identified numerically on one axis and alphabetically on the other axis or in distances in different compass directions from the grid origin. Interior walls are treated as extensions of the floor along the horizontal plane. An example of a structure interior reference coordinate system using letters and numbers in shown in Figure 3.1. An example land area reference coordinate system using distance from an origin along north-south and east-west lines is shown in Figure 3.2.

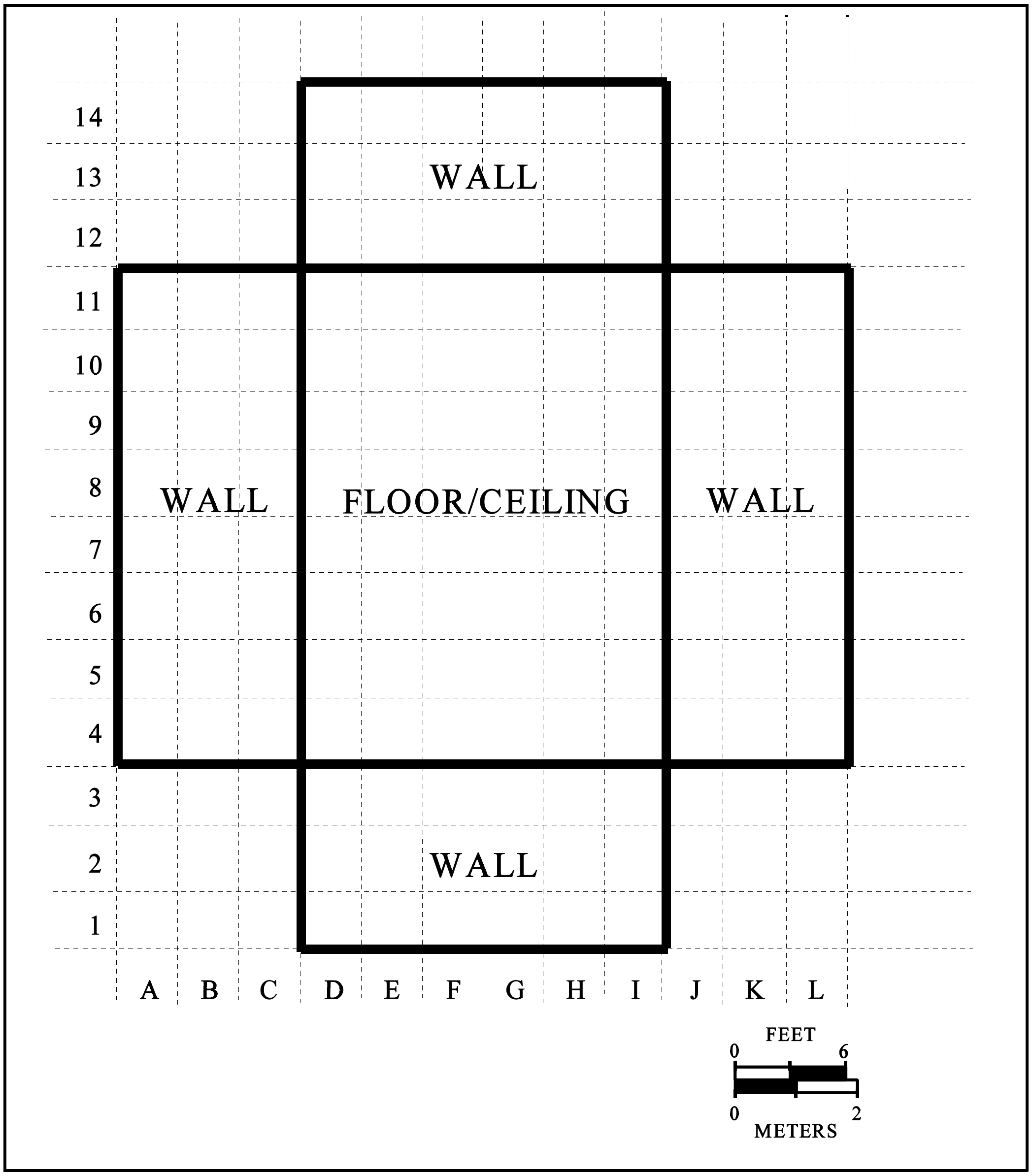

Figure 3.1 Sample Indoor Reference Coordinate System.